

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
21 May 2004 (21.05.2004)

PCT

(10) International Publication Number  
**WO 2004/042203 A2**

- (51) International Patent Classification<sup>7</sup>: **F01N** (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.
- (21) International Application Number: PCT/US2003/034698
- (22) International Filing Date: 31 October 2003 (31.10.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 60/422,541 31 October 2002 (31.10.2002) US
- (71) Applicant: **WHITE BROTHERS PERFORMANCE PRODUCTS, INC.** [US/US]; 24845 Corbit Place, Yorba Linda, CA 92887 (US).
- (72) Inventor: **LEWIS, Simon, J.**; 3280 Ulla Lane, Lake Elsinore, CA 92530 (US).
- (74) Agents: **TANGREN, Dana, L.** et al.; Workman Nydegger, 1000 Eagle Gate Tower, 60 East South Temple, Salt Lake City, UT 84111 (US).
- (84) Designated States (*regional*): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— *without international search report and to be republished upon receipt of that report*
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: MUFFLER WITH SPARK ARRESTOR

(57) Abstract: A muffler includes a tubular body having an interior surface extending between a first end and an opposing second end, the interior surface bounding a chamber. An exhaust cap is disposed on the second end of the tubular body, the exhaust cap having an interior surface bounding a channel that communicates with the chamber. An inlet cap is disposed on the first end of the tubular body. A perf tube is longitudinally disposed within the chamber of the tubular body. A spark arrestor includes a tubular neck advanced within the channel of the exhaust cap toward the body. A spark barrier is mounted on an end of the tubular neck so as to be at least partially disposed within the perf tube, the spark barrier being comprised of a sheet of mesh or porous material.

WO 2004/042203 A2

## MUFFLER WITH SPARK ARRESTOR

### BACKGROUND OF THE INVENTION

#### 1. The Field of the Invention

5 The present invention relates to mufflers and components thereof. More specifically, the present inventions relates to mufflers and components thereof for motorcycles, ATVs and other personal on- and off-road vehicles.

#### 2. The Relevant Technology

10 Personal motorcraft such as motorcycles and ATVs use mufflers to reduce noise. More recently, off-road vehicles have been required to incorporate a spark arrestor in the muffler to prevent a spark or carbon particle from exiting with the exhaust and potentially creating a fire. Conventional mufflers comprise a canister housing a noise reducing packing material. A separate and discrete outlet cap is bolted on the tail end of the canister. A screen type spark arrestor is typically disposed between the end cap and the canister.

15 Although conventional mufflers generally sever their intended function, they have a number of shortcomings. For example, conventional mufflers are relatively expensive in that a uniquely configured muffler must be designed for each style of motorcraft. Furthermore, because spark arrestors are required to have a defined area size, most mufflers are larger and heavier than necessary to accommodate the spark  
20 arrestor. With the increasing demand for high performance motorcraft, it is desirable to provide mufflers that are relatively inexpensive and which provide and/or enable the user to optimize performance characteristics. Many conventional mufflers also have the downside in that their design results in relatively frequent clogging of the spark arrestor with particles from the exhaust. Such clogging has a detrimental affect  
25 on engine performance.

### BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the present invention will now be discussed with reference to the appended drawings. It is appreciated that these drawings depict only  
30 typical embodiments of the invention and are therefore not to be considered limiting of its scope.

Figure 1 is a perspective view of a muffler;

Figure 2 is a top plan view of the muffler shown in Figure 1;

Figure 3 is a disassembled view of the muffler shown in Figure 1;

Figure 4 is a cross sectional side view of the canister shown in Figure 3;

Figure 5 is a cross sectional side view of the canister shown in Figure 4 taken along lines 5-5;

Figure 6 is a cross sectional side view of the muffler shown in Figure 2 taken along lines 6-6;

5        Figure 7 is an elevated right end view of the muffler shown in Figure 1;

Figure 8 is a perspective view of a spark arrestor of the muffler shown in Figure 1;

Figures 9 and 10 are alternative embodiments of folds for the spark barrier of the spark arrestor shown in Figure 8;

10        Figure 11 is a side view of an alternative embodiment of a spark barrier having a conical configuration;

Figure 12 is a side view of an alternative embodiment of a spark barrier having a domed shaped configuration;

15        Figure 13 is a side view of an alternative embodiment of a spark barrier having a cylindrical configuration;

Figure 14 is an elongated cross sectional side view of an alternative embodiment of a spark barrier for the spark arrestor shown in Figure 8;

Figure 15 is another elongated cross sectional side view of an alternative embodiment for a spark barrier of the spark arrestor shown in Figure 8;

20        Figure 16 is a perspective view of an alternative embodiment of a spark arrestor;

Figure 17 is a top plan view of a blank used to make the spark barrier of the spark arrestor shown in Figure 16;

Figure 18 is a perspective view of the spark barrier shown in Figure 16; and

25        Figure 19 is a perspective view of a nozzle used to replace the spark arrestor shown in Figure 8.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

30        Depicted in Figures 1 and 2 is one embodiment of an inventive muffler 10 incorporating features of the present invention. Muffler 10 has an inlet end for receiving exhaust from an engine and an opposing outlet end 14 for discharging the exhaust to the surround environment. Muffler 10 can be used in association with motorcycles, ATVs, or other personal motorcraft.

As depicted in Figure 3, muffler 10 comprises a canister 20 which includes a tubular body 22 having an exhaust cap 24 integrally formed thereon. Tubular body 22

has an exterior surface 26 and an interior surface 28 each extending between a first end 30 and an opposing second end 32. As depicted in Figure 4, interior surface 28 bounds an elongated chamber 29 having a central longitudinal axis 31 extending therethrough. Chamber 29 communicates with the exterior through an opening 33 at first end 30. A plurality of spaced apart holes 35 extend through tubular body 22 adjacent to opening 33. In the embodiment depicted, tubular body 22 has a substantially uniform transverse cross section along the length thereof.

Depicted in Figure 5 is a transverse cross section of tubular body 22. As shown therein, tubular body 22 further comprises a first side wall 34 and an opposing second side wall 36 each extending between a top wall 38 and an opposing bottom wall 40. Each of side walls 34 and 36 has an outwardly bowed inside surface 42 and outside surface 44. Each of top wall 38 and bottom wall 40 have a substantially flat inside surface 46 and outside surface 48. Each of top wall 38 and bottom wall 40 have a thickness  $T_1$  typically in a range between about 0.06 inches to about 0.09 inches while each of side walls 34 and 36 have a thickness  $T_2$  typically in a range between about 0.03 inches to about 0.07 inches. Other dimensions can also be used.

Although not required, in the embodiment depicted thickness  $T_1$  is greater than thickness  $T_2$ . For example, in one embodiment thickness  $T_1$  is about 0.075 inches while thickness  $T_2$  is about 0.05 inches. The unique configuration and thicknesses of the walls of body 22 produce a number of unique benefits. For example, depicted in Figures 1 and 2 is a mounting bracket 50 secured to top wall 38. Mounting bracket 50 comprises a base plate 52 having a substantially flat bottom surface 53. A brace 54 is integrally formed with and upstands from base plate 52. Brace 54 has an opening 56 extending therethrough to facilitate attachment to the vehicle. It is appreciated that opening 56 can be replaced with any attachment mechanism for securing mounting bracket 50 to the vehicle.

As a result of outside surface 48 of top wall 38 being flat, base plate 52 can be easily mounted at any select lateral, longitudinal, or angled location on outside surface 48 of top wall 38 so that muffler 10 can fit a variety of different motor vehicles. That is, many prior art mufflers have a circular or oval exterior transverse cross section. By changing the lateral position or angled orientation of the mounting bracket on such mufflers, the height and projected orientation of the mounting bracket also changes. Furthermore, the base plate of the mounting bracket is typically welded to the canister. To facilitate welding, the base plate must fit in a close tolerance with the

surface of the canister. On oval or circular mufflers, the fit between the canister and the mounting bracket changes as the mounting bracket is moved on the canister. Accordingly, in conventional mufflers it is necessary to fabricate a number of different sized and shaped canisters and/or mounting brackets so as to enable the mufflers to fit a variety of different styles of motor vehicles. In contrast, by having flat mating surfaces between canister 20 and mounting bracket 50, a single configuration of canister 20 and mounting bracket 50 can be used to fit a variety of different motor vehicles. For example, in one embodiment a standardized billet machined mounting bracket can be positioned and fixed exactly where it is needed on canister 20 without the use of alignment spacers.

Mounting bracket 50 is secured to canister 20 using welding, rivets, or other conventional techniques. Depending on the style of vehicle on which muffler 10 is to be mounted, any number of mounting brackets 50 can be mounted on top wall 38 and/or bottom wall 40 at any desired location or orientation. Top wall 38 has the thickness  $T_1$ , as discussed above, which is sufficient to enable welding or other desired securing techniques and to subsequently withstand the forces applied during use of the vehicle. In contrast, because a mounting bracket is not attached to side wall 34 or 36, these walls can have a reduced thickness. By reducing the thickness of side walls 34 and 36, the weight of canister 20 is reduced and the size of chamber 29 increased. The size of chamber 29 is further increased by the outward bowing of side walls 34 and 36. As discussed below in greater detail, increasing the size of chamber 29 maximizes the amount of noise absorbing packing material that can be housed therein.

In alternative embodiments it is appreciated that each of the walls 34-40 can have common or different thicknesses. For example, top wall 38 can have a different thickness than bottom wall 40. In yet another embodiment, all of the walls can have the same thickness. In some embodiments, it is also appreciated that top wall 38 and bottom wall 40 need not be flat. For example, tubular body 22 can have a transverse cross sectional configuration that is circular, oval, square, or any other polygonal or irregular configuration. It is also appreciated that the configuration of the interior surface of body 22 can be the same as or different from the exterior surface of body 22.

As previously discussed, in the embodiment depicted exhaust cap 24 is integrally formed with tubular body 22. As depicted in Figure 4, exhaust cap 24

comprises an annular side wall 55 having an exterior surface 56 that radially inwardly tapers, at an angle relative to tubular body 22, from a first end 58 to an opposing second end 60. Although not necessarily required, exhaust cap 24 is shown having a greater thickness than the wall of body 22. This enables exhaust cap 24 to be  
5 machined or otherwise mechanically processed to obtain the desired configuration.

Specifically, first end 58 of exhaust cap 24 has an inside face 64 that is integrally formed with second end 32 to tubular body 22 and radially inwardly projects therefrom. Second end 60 of exhaust cap 24 terminates at an exposed end face 62. End face 62 is disposed in a plane 65 that forms an inside angle  $\theta_1$  with  
10 central longitudinal axis 31 that is typically less than about  $80^\circ$ . In one embodiment the angle  $\theta_1$  is in a range between about  $65^\circ$  to about  $80^\circ$ . Other angles can also be used.

Recessed into end face 62 of exhaust cap 24 is a pocket 66 that terminates at an annular shoulder 67. Extending between pocket 66 and inside face 64 of exhaust  
15 cap 24 is a channel 68 communicating with chamber 29. Channel 68 is curved or angled relative central longitudinal axis 31 of tubular body 20. A tubular stem 70 projects from inside face 64 of exhaust cap 24 so as to encircle a portion of channel 68 and extend into chamber 29. As will be discussed below in greater detail, a groove 72 extends from pocket 66 into the upper side of second end 60 of end cap 24.  
20 Furthermore, a hole 74 extends through second end 60 of end cap 24 and into pocket 66 at a location opposite of groove 72.

In one embodiment, canister 20 is formed by impact extrusion. This process enables the integral formation of body 22 and exhaust cap 24 where exhaust cap 24 has an increased thickness. In other embodiments, canister 20 can be formed by  
25 various conventional molding processes. It is also appreciated that canister 20 can be formed with body 22 and exhaust cap 24 being separate and discrete members. In this embodiment, body 22 and exhaust cap 24 are secured together such as by welding, screwing, bolting, or any other conventional technique. Canister 20 is typically made of metal such as aluminum. Alternatively, canister 20 can be made of other metals or  
30 from non-metals such as fiber reinforced composite materials.

Conventional mufflers are formed with the end cap being separate from the body. In such embodiments, separate mounting flanges and fasteners, such as bolts, are required to secure the elements together. By forming canister 20 as a single integral unit, canister 20 is formed so as to minimize weight, materials, and

manufacturing costs.

Returning to Figure 3, muffler 10 further comprises a perf tube 80 having an exterior surface 82 and an interior surface 84 each extending between a first end 86 and an opposing second end 88. Interior surface 84 bounds a passageway 90  
5 extending therethrough. Extending between exterior surface 82 and an interior surface 84 along the length of perf tube 80 are a plurality of perforations 92 (Figure 6).

Coupled with and extending from perf tube 80 is an exhaust pipe 94. Exhaust pipe 94 couples with the engine to deliver the exhaust from the engine to muffler 10.  
10 Mounted at or adjacent to the coupling between perf tube 80 and exhaust pipe 94 is an inlet cap 100. As shown in Figures 3 and 7, inlet cap 100 comprises an annular base 102 that is welded or otherwise secured to perf tube 80 and/or exhaust pipe 94 and radially outwardly projects therefrom. An annular sleeve 104 having spaced apart holes 106 extending therethrough, projects from base 102.

15 During assembly as depicted in Figure 6, perf tube 80 is received within canister 20 through opening 33. Second end 88 of perf tube 80 is advanced with chamber 29 so as to engage inside of stem 70 of exhaust cap 24. Simultaneously, sleeve 104 of inlet cap 100 is received within opening 33 of canister 20 so that inlet cap 100 covers opening 33. Fasteners 110, such as bolts or rivets, are passed into  
20 holes 35 of canister 20 and holes 106 of inlet cap 100 so as to secure inlet cap 100 to canister 20. An annular seal 102 is disposed therebetween so as to form an air tight seal.

As depicted in Figures 3 and 6, encircling perf tube 80 and extending along the length thereof is a heat shield 114. In one embodiment, heat shield 114 comprises  
25 a tubular member formed of mesh screen. Heat shield 114 allows the exhaust to pass therethrough but prevents the noise absorbing packing, discussed below, from traveling therethrough and into passageway 90 of perf tube 80.

As also depicted in Figures 3 and 6, disposed between heat shield 114 and canister 20 and extending between exhaust cap 24 and inlet cap 100 is noise absorbing  
30 packing 116. Although packing 116 is illustrated in Figure 3 as an integral member, packing 116 typically comprises loosely packed fibers such as fiberglass, E-glass, or other conventional materials known to those skilled in the art.

During operation, the engine exhaust enters passageway 90 of perf tube 80 from exhaust pipe 94. As the exhaust travels through passageway 90, portions of the

exhaust and accompanying sound waves disperse out through perforations 92 of perf tube 80 and through heat shield 114 so as to travel through noise absorbing packing 116. In turn, noise absorbing packing 116 dampens the sound waves before the exhaust exits out through channel 68 of exhaust cap 24.

5           Returning to Figure 3, muffler 10 also comprises a removable spark arrestor 120. As depicted in Figure 8, spark arrestor 120 comprises a curved or bent tubular neck 122 having an interior surface 124 and an exterior surface 126 extending between a first end 128 and an opposing second end 130. Interior surface 124 bounds a passageway 132 longitudinally extending therethrough. An annular flange 134  
10       radially outwardly projects from first end 128 of neck 122. An annular flange 160 also radially outwardly projects from neck 122 toward second end 130.

          Outwardly projecting from flange 134 so as to cover the opening to passageway 132 at first end 128 of neck 122 is a spark barrier 136. Spark barrier 136 has a substantially frustoconical configuration which includes an enlarged mounting  
15       end 192 that constricts to an opposing free end 194. As will be discussed below in greater detail, a plurality of exposed folds 137 longitudinally extend between mounting end 192 and free end 194. Mounting end 192 is secured to flange 134 such as by welding or other fastening techniques. Spark barrier 136 is comprised of a sheet  
20       of mesh or porous material typically having an open area in a range between about 25% to about 50%. The mesh material is typically comprised of wire but can also be comprised of other non-flammable materials. In contrast to a wire type mesh, spark barrier 136 can be comprised of a perforated or otherwise porous sheet of material such as a perforated metal sheet. In either event, the materials allows the free flow of exhaust gas therethrough but acts as a filter to prevent the passage of sparks or  
25       particles therethrough.

          Spark arrestor 120 is removably held in place by a retention ring 164 having a central port 165 extending therethrough. Retention ring 164 has a top end with a tab 166 projecting therefrom and an opposing bottom end with a threaded hole 168 formed thereat.

30           During assembly as depicted in Figure 6, spark barrier 136 is passed through passageway 68 of exhaust cap 24 and into passageway 90 of perf tube 80 until flange 160 of spark arrestor 120 is stopped within pocket 66 of exhaust cap 24. Retention ring 164 is then inserted within pocket 66 so that flange 160 is compressed between exhaust cap 24 and retention ring. Retention ring 164 is secured in place by first



inserting tab 166 of retention ring 164 into groove 72 formed in pocket 66 (see Figure 8). The remainder of retention ring 164 is then pushed into pocket 66. Once inserted, a threaded fastener 170 is passed through hole 74 of exhaust cap 24 and threaded into hole 168 of retention ring 164, thereby removably securing retention ring 164 to canister 20 so as to hold spark arrestor 120 in position. To selectively remove or replace spark arrestor 120, fastener 170 is simply unthreaded and retention ring 164 removed.

One of the benefits of spark arrestor 120 comprising elongated neck 122 is that spark barrier 136 is spaced apart from the end of muffler 10. Specifically, spark barrier 136 is advanced part way into perf tube 80. Many of the particles entering perf tube 80 from exhaust pipe 94 travel down perf tube 80, past spark barrier 136, and collect at the end of muffler 10 against flange 160 of neck 122. As a result, a majority of the particles do not collect against spark barrier 136. This is beneficial in that the collection of particles can clog spark barrier 136 and thus hamper engine performance. In alternative embodiments, however, it is appreciated that spark barrier 136 can be placed at any desired location along muffler 10 and even at the end thereof. As such, in alternative embodiments spark barrier 136 need not be mounted on an elongated neck but can be mounted on any form of base such as a metal ring.

Current US legislative standards require that spark barriers be capable of capturing carbon particles with a diameter greater than 0.023 inches (0.58 mm) and have a total open area 200% greater than the smallest restriction in the exhaust port coming from the engine. Conventional spark arrestors use smooth surface, substantially dome shaped spark barriers to achieve the desired requirements. The problem with conventional spark barriers, however, is that they occupy a relatively large space, particularly in diameter. The spark barrier is often the limiting factor in sizing the muffler. That is, conventional mufflers are often made larger than required so as to fit the spark barrier. By increasing the size of the muffler to occupy the spark barrier, the weight of the muffler goes up, thereby decreasing performance of the corresponding vehicle.

One embodiment of the present invention is configured to minimize the size of spark barrier 136 by concentrating the area of mesh material per volume of space. In so doing, the size of the muffler can be decreased, thereby decreasing its weight. Alternatively, the muffler size can be retained but more packing material added so as to further decrease sound. In one embodiment, the concentration of area of mesh

material per volume of space is increased by constricting the spark barrier 136 so that a plurality of folds are formed thereon. For example, spark barrier 136 is comprised of a flat, round sheet of mesh or porous material that is pressed in a die so as to have the frustoconical configuration having the folds 137 extending along the length thereof. The formation of folds 137 increases the surface area of material per volume of space as compared to a plane frustoconical configuration. As used herein, the term "folds" is broadly intended to include channels, grooves, ribs, waves, flutes, bends, and the like which are either regular or irregular. For example, depicted in Figure 9 is one embodiment of substantially square shaped folds 138 while Figure 8 depicts substantially triangular shaped folds 140. It is appreciated that any fold configuration can be use.

In contrast to having a frustoconical configuration, spark barrier 136 can have a variety of different configurations. For example, depicted in Figure 11 is a spark barrier 136A having a conical configuration with folds 137 extending along the length thereof. Depicted in Figure 12 a spark barrier 136B having a domed shaped configuration with folds 137 formed thereon. In the embodiment depicted in Figure 13, in contrast to being taped, a spark barrier 136C is shown having a substantially cylindrical configuration. In contrast to having a substantially circular transverse cross sectional configuration, spark barrier 136C can be formed having a transverse cross sectional configuration that is square, triangular, or any other polygonal or irregular configuration. To prevent the exhaust from passing straight through spark barrier 136 without passing through the mesh or porous material, a cap 196 or other sealant is secured over free end 194.

As also depicted in Figure 13, the folds need not extend longitudinally along the spark barrier. For example, folds 198 can be formed that radially encircle the spark barrier or folds 199 can be formed that are angled so as to spiral like threads. As such, in each embodiment the folds can be positioned at any desired orientation or combination of orientations. Figure 14 shows a longitudinal cross section view of another alternative embodiment of a spark barrier 142 having folds 144 that radially encircle spark barrier 142. In this embodiment the mesh or porous material covers the free end of the spark barrier 144. In yet another embodiment depicted in Figure 15, a longitudinal cross section view a spark barrier 150 is shown having a substantially frustoconical or cylindrical side wall 152 that terminates at an end face 154. Rather than extending flat across end face 154, however, a recessed pocket 156 is formed on

end face 154 so as to increase the concentration of mesh material per volume of space. Additional folds can be formed along the surface of spark barrier 150 as discussed above.

Depicted in Figure 16 is another alternative embodiment of a spark arrestor 5 202 where like elements are identified by like reference characters. Spark arrestor 202 comprises neck 122 as previously discussed. Mounted on neck 122 is a spark barrier 204. In contrast to spark barrier 136 which is die pressed from a circular sheet of material, spark barrier 204 is formed from an arched sheet 206 of mesh or porous material, as depicted in Figure 17, having opposing side edges 208 and 210. Once cut 10 or formed to size, arched sheet 206 is passed through a machine that creates all of the desired folds thereon. Next, arched sheet 206 is rolled into a frustoconical configuration with side edges 206 and 208 being adjacently disposed. As depicted in Figure 18, side edges 206 and 208 are secured together such as by welding, soldering, crimping or other conventional techniques so as to form spark barrier 204. In this 15 embodiment, spark barrier 204 has a free end 212 with an opening 214 formed thereat.

Returning of Figure 16, spark barrier 204 is mounted on flange 134 of neck 122 so as to cover the end of neck 122. To prevent the exhaust gas from simply passing out through opening 214, a cap 216 is mounted on free end 212. In contrast 20 to using cap 216, opening 214 can be sealed closed by using brazing, soldering, crimping, welding, or a variety of other conventional techniques.

It is appreciated that any number of folds can be formed on a corresponding spark barrier. For example, in one embodiment a spark barrier can have more than four, more than seven, more than ten, or more than twenty separate and discrete folds. 25 In yet another embodiment, one or more continuous folds can repeatedly encircle and/or extend back and forth along a spark barrier.

Returning to Figure 3, depending on the intended riding environment for the vehicle, spark arrestor 120 can be selectively replaced with a nozzle 174 or a nozzle 190. As shown in Figure 19, nozzle 174 comprises a tubular neck 176 having an 30 annular flange 178 encircling and radially outwardly projecting therefrom. A threaded hole 184 extends through flange 178. Neck 176 has an interior surface 180 that bounds a passageway 182 extending through neck 176. Formed on interior surface 180 are a plurality of rifled grooves 183. Once spark arrestor 150 is removed, nozzle 174 is attached by simply sliding neck 176 into channel 68 of exhaust cap 24

until flange 178 is received within pocket 66 of exhaust cap 24. Fastener 170 (Figure 8) is then passed through hole 74 in end cap 24 and into threaded hole 184, thereby securing nozzle 178 to canister 20.

5 Rifled grooves 183 help to concentrate and direct the exhaust and sound waves exiting through nozzle 174. In alternative embodiments, rifled grooves 183 are eliminated so that interior surface 180 of neck 176 is smooth. For example, nozzle 190 simply comprises an annular ring having threaded hole 184 formed thereon. Nozzle 190 can be positioned within pocket 66 and secured therein by fastener 170. One embodiment of the present invention thus includes a plurality of interchangeable  
10 nozzles 174 wherein passageway 182 of each nozzle is constricted to a different minimum diameter. By changing the minimum diameter, the exhaust back pressure within muffler 10 changes thereby also changing the exhaust sound and engine performance. Accordingly, the end user can selectively adjust sound and engine performance by selecting different nozzles.

15 It is appreciated that the present invention has a number of unique features that can be used either in combination as disclosed above in muffler 10 or can be used independently. For example, tubular body 22 having the flat surfaces and other configurations can be used with a discrete, separately attachable end cap and a conventional spark arrestor. Likewise, the integral canister 20 can also be used with a  
20 conventional spark arrestor. In addition, spark arrestor 120 and/or the related spark barrier can be used with conventional mufflers. As such, it is appreciated that the various features and elements disclosed herein can be mixed and matched with different features disclosed herein and with prior art assemblies to form a variety of alternative novel embodiments.

25 The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of  
30 equivalency of the claims are to be embraced within their scope.

## CLAIMS

What is claimed is:

1. A muffler canister comprising:  
a tubular body having an interior surface extending between a first end  
5 and an opposing second end, the interior surface bounding a chamber; and  
an exhaust cap being integrally formed on the second end of the  
tubular body, the exhaust cap having an interior surface bounding a channel  
extending through the exhaust cap, the channel being in communication with  
the chamber, at least a portion of the exhaust cap having a thickness that is  
10 different than a thickness of the tubular body.
2. A muffler canister as recited in claim 1, wherein the body and exhaust  
cap are comprised of a metal and are formed using impact extrusion.
3. A muffler canister as recited in claim 1, wherein the exhaust cap  
comprises a tubular side wall having a first end integrally formed with the second end  
15 of the body and an opposing second end terminating at an end face.
4. A muffler canister as recited in claim 3, wherein the body has a central  
longitudinal axis extending through the chamber thereof, the end face of the exhaust  
cap being disposed in a plane that forms an inside angle with the central longitudinal  
axis that is less than about 80°.
- 20 5. A muffler canister as recited in claim 3, wherein the side wall of the  
exhaust cap has an exterior surface that radially inwardly tapers from the first end to  
the second end thereof.
6. A muffler canister as recited in claim 3, wherein the first end of the  
side wall of the exhaust cap has an inside face that radially inwardly projects relative  
25 to the body, a tubular stem projects from the inside face toward the body, the tubular  
stem bounding at least a portion of the channel extending through the exhaust cap.
7. A muffler canister as recited in claim 1, wherein the body has a central  
longitudinal axis extending therethrough, the channel of the exhaust cap being bent or  
curved relative to the central longitudinal axis.
- 30 8. A muffler canister as recited in claim 1, wherein the tubular body  
comprises a top wall and a pair of opposing side walls extending therefrom, the top  
wall having a substantially flat exterior surface extending along the length thereof.
9. A muffler comprising:  
a muffler canister as recited in claim 1;

an inlet cap disposed at the first end of the tubular body;  
a perf tube longitudinally disposed within the muffler canister; and  
noise absorbing packing disposed between the perf tube and the  
canister.

- 5           10. A muffler as recited in claim 9, further comprising a spark arrestor, the  
spark arrestor comprising:

a tubular neck removably disposed within the channel of the end cap,  
the tubular neck having a first end and an opposing second end; and

- 10           a spark barrier mounted at the first end of the tubular neck so as to be  
disposed within the muffler canister, the spark barrier being comprised of a  
mesh or porous material having one or more exposed folds so as to increase  
the surface area of the mesh or porous material per volume of space.

11. A spark arrestor for use with a muffler, the spark arrestor comprising:  
a base having an opening extending therethrough; and

- 15           a spark barrier mounted to the base, the spark barrier being comprised  
of a sheet of mesh or porous material having a plurality of exposed folds  
through which exhaust gas can pass, the folds increasing the surface area of  
the mesh or porous material per volume of space.

12. A spark arrestor as recited in claim 11, wherein the base comprises a  
20 tubular neck having a first end and an opposing second end, the spark barrier being  
mounted to the first end of the tubular neck so that exhaust gas can pass through the  
spark barrier and into the tubular neck.

13. A spark arrestor as recited in claim 12, wherein the tubular neck is  
curved or bent.

- 25           14. A spark arrestor as recited in claim 11, wherein the spark barrier has at  
least a substantially domed, conical, or frustoconical configuration.

15. A spark arrestor as recited in claim 11, wherein the spark barrier has a  
mounting end secured to the base and an opposing free end spaced apart from the  
mounting end, each of the plurality of folds longitudinally extending between the  
30 mounting end and the free end.

16. A spark arrestor as recited in claim 15, wherein the free end of the  
spark barrier is sealed closed.

17. A spark arrestor as recited in claim 11, wherein the spark barrier has an  
elongated substantially tubular configuration.

18. A spark arrestor as recited in claim 11, wherein the spark barrier has a substantially polygonal transverse cross section.

19. A spark arrestor as recited in claim 11, wherein the plurality of folds comprises at least four discrete folds.

5 20. A spark arrestor as recited in claim 11, wherein the plurality of folds comprises at least seven discrete folds.

21. A spark arrestor for use with a muffler, the spark arrestor comprising:  
a base having an opening extending therethrough; and  
a spark barrier mounted to the base, the spark barrier being comprised  
10 of a sheet of mesh or porous material having at least a substantially tubular, domed, conical, or frustoconical configuration, the sheet of mesh material further comprising:

a plurality of discrete exposed folds through which exhaust gas can pass; or

15 a least one exposed continuous fold that repeatedly extends around or along the sheet.

22. A spark arrestor as recited in claim 21, wherein the base comprises a tubular neck having a first end and an opposing second end, the spark barrier being mounted to the first end of the tubular neck so that exhaust gas can pass through the  
20 spark barrier and into the tubular neck.

23. A spark arrestor as recited in claim 21, wherein the spark barrier has a mounting end secured to the base and an opposing free end spaced apart from the mounting end, each of the plurality of discrete exposed folds longitudinally extending between the mounting end and the free end.

25 24. A spark arrestor as recited in claim 21, wherein the spark barrier has a mounting end secured to the base and an opposing free end spaced apart from the mounting end, the free end of the spark barrier being sealed closed.

25. A muffler comprising:  
a tubular body having an interior surface extending between a first end  
30 and an opposing second end, the interior surface bounding a chamber;  
an exhaust cap disposed on the second end of the tubular body, the exhaust cap having an interior surface bounding a channel extending through the exhaust cap, the channel being in communication with the chamber;  
an inlet cap disposed on the first end of the tubular body;

a perf tube longitudinally disposed within the chamber of the tubular body; and

a spark arrestor comprising:

5 a tubular neck having a first end and an opposing second end, the second end being removably secured to the exhaust cap such that the first end is advanced within the channel of the exhaust cap toward the body; and

10 a spark barrier mounted on the first end of the tubular neck so as to be at least partially disposed within the perf tube, the spark barrier being comprised of a sheet of mesh or porous material.

26. A muffler as recited in claim 25, wherein the exhaust cap is integrally formed with the second end of the tubular body.

15 27. A muffler canister as recited in claim 25, wherein the body has a central longitudinal axis extending through the chamber thereof, the channel of the exhaust cap being bent or curved relative to the central longitudinal axis.

28. A muffler canister as recited in claim 27, wherein the tubular neck of the spark arrestor received within the channel of the exhaust cap is curved or bent.

29. A muffler canister as recited in claim 25, wherein the body has a substantially constant transverse cross section along the length thereof.

20 30. A muffler canister as recited in claim 25, wherein the spark barrier has one or more exposed folds through which exhaust gas can pass, the one or more folds increasing the surface area of the mesh or porous material per volume of space.

31. A muffler canister as recited in claim 25, wherein the spark barrier has at least seven exposed folds.

25 32. A muffler canister as recited in claim 25, further comprising noise absorbing packing disposed between the perf tube and the body.

30 33. A muffler canister comprising:  
a tubular body having a first end and an opposing second end, the tubular body comprising a top wall, a bottom wall, and a pair of opposing side walls extending therebetween, the top wall having a substantially flat exterior surface extending along the length thereof; and

a mounting bracket secured on the substantially flat exterior surface of the top wall.

34. A muffler canister as recited in claim 33, wherein at least one of the



side walls has an outwardly bowed exterior surface extending along the length thereof.

35. A muffler canister as recited in claim 33, wherein the bottom wall has a substantially flat exterior surface extending along the length thereof.

5        36. A muffler canister as recited in claim 33, wherein the top wall has a thickness and each of the side walls has a thickness, the thickness of the top wall being greater than the thickness of at least one of the side walls.

37. A muffler canister as recited in claim 33, wherein the body has a substantially uniform transverse cross section along the length thereof.

10       38. A muffler canister as recited in claim 33, further comprising an exhaust cap integrally formed on the second end of the tubular body, the exhaust cap having an interior surface bounding a channel extending through the exhaust cap so as to communicate with the body.

39. A muffler comprising:

15       a muffler canister as recited in claim 33, the body having an interior surface bounding a chamber;

an exhaust cap disposed on the second end of the tubular body, the exhaust cap having an interior surface bounding a channel extending through the exhaust cap so as to communicate with the chamber of the body;

20       an inlet cap disposed on the first end of the tubular body;

a perf tube longitudinally disposed within the muffler canister; and

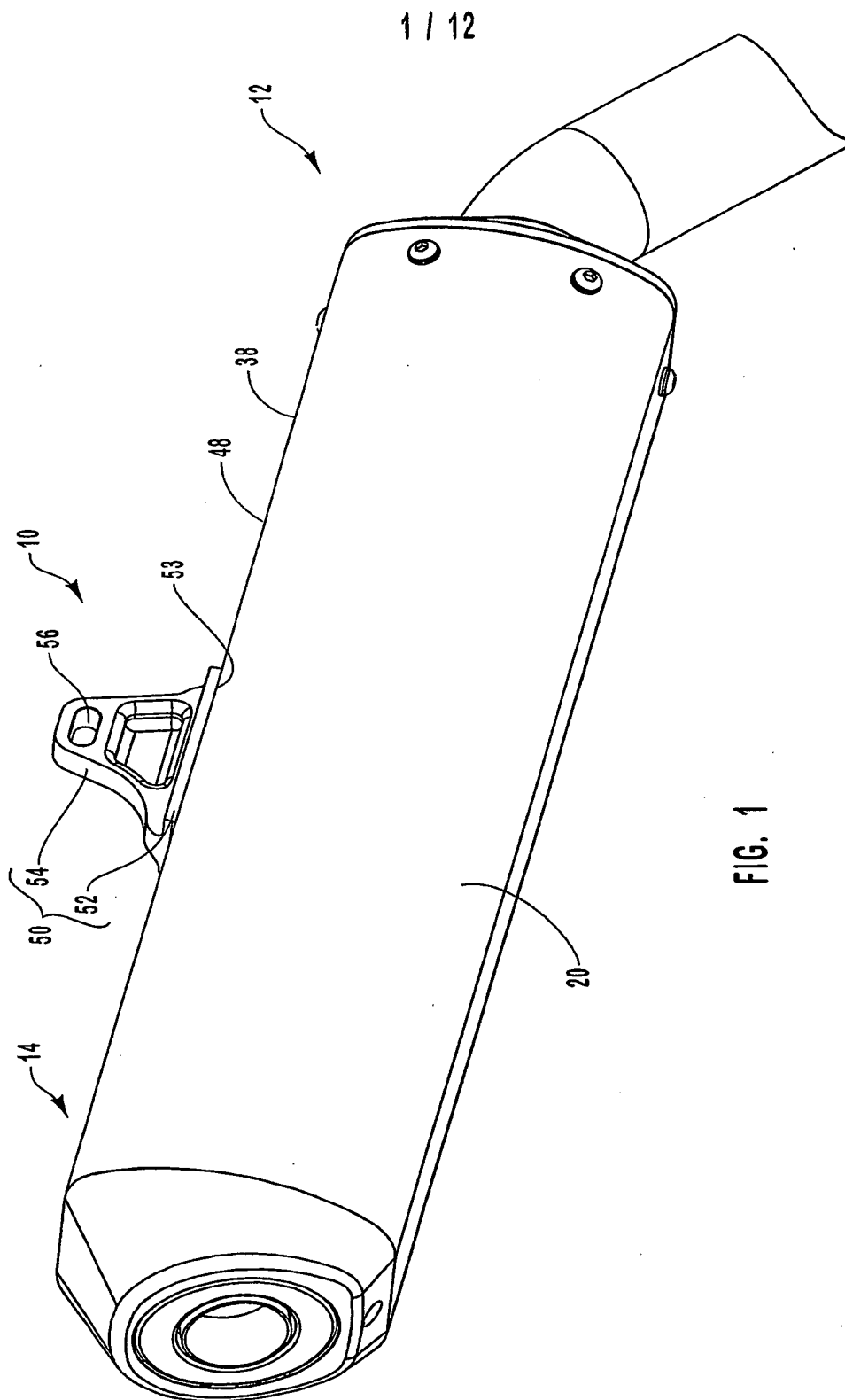
noise absorbing packing disposed between the perf tube and the canister.

25       40. A muffler as recited in claim 39, further comprising a spark arrestor, the spark arrestor comprising:

a tubular neck removably disposed within the channel of the end cap, the tubular neck having a first end and an opposing second end; and

30       a spark barrier mounted at the first end of the tubular neck so as to be at least partially disposed within the chamber of the body, the spark barrier being comprised of a sheet of mesh or porous material.

41. A muffler as recited in claim 40, wherein the sheet of mesh or porous material has a plurality of folds so as to increase the surface area of the mesh or porous material per volume of space.



2 / 12

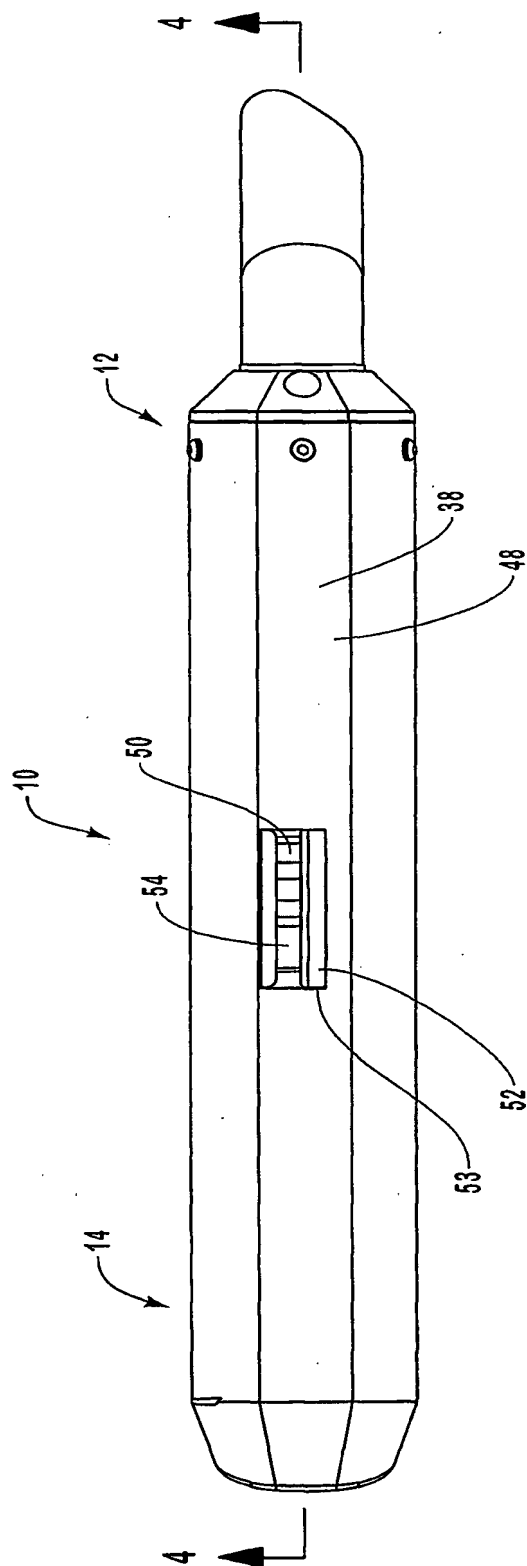
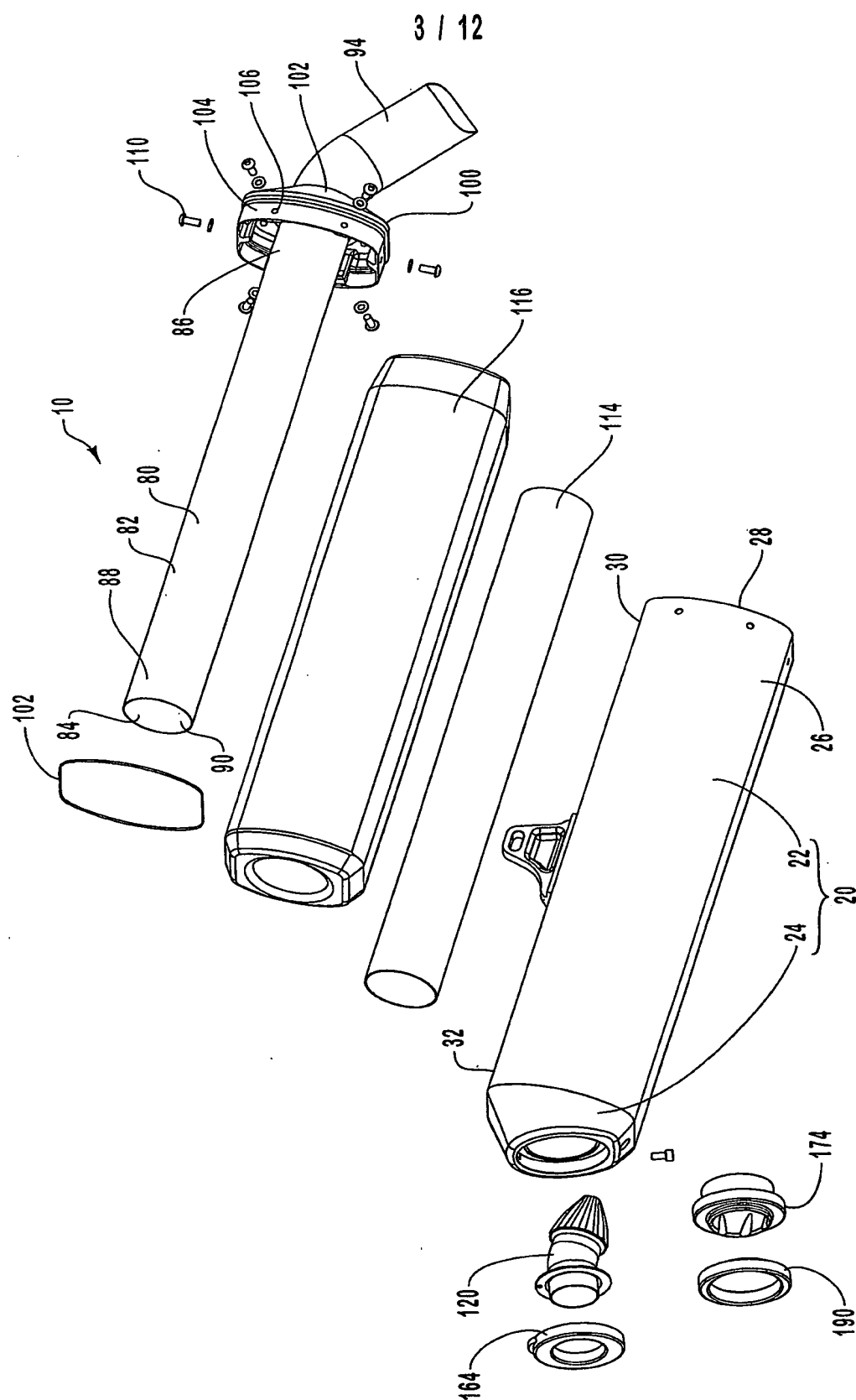
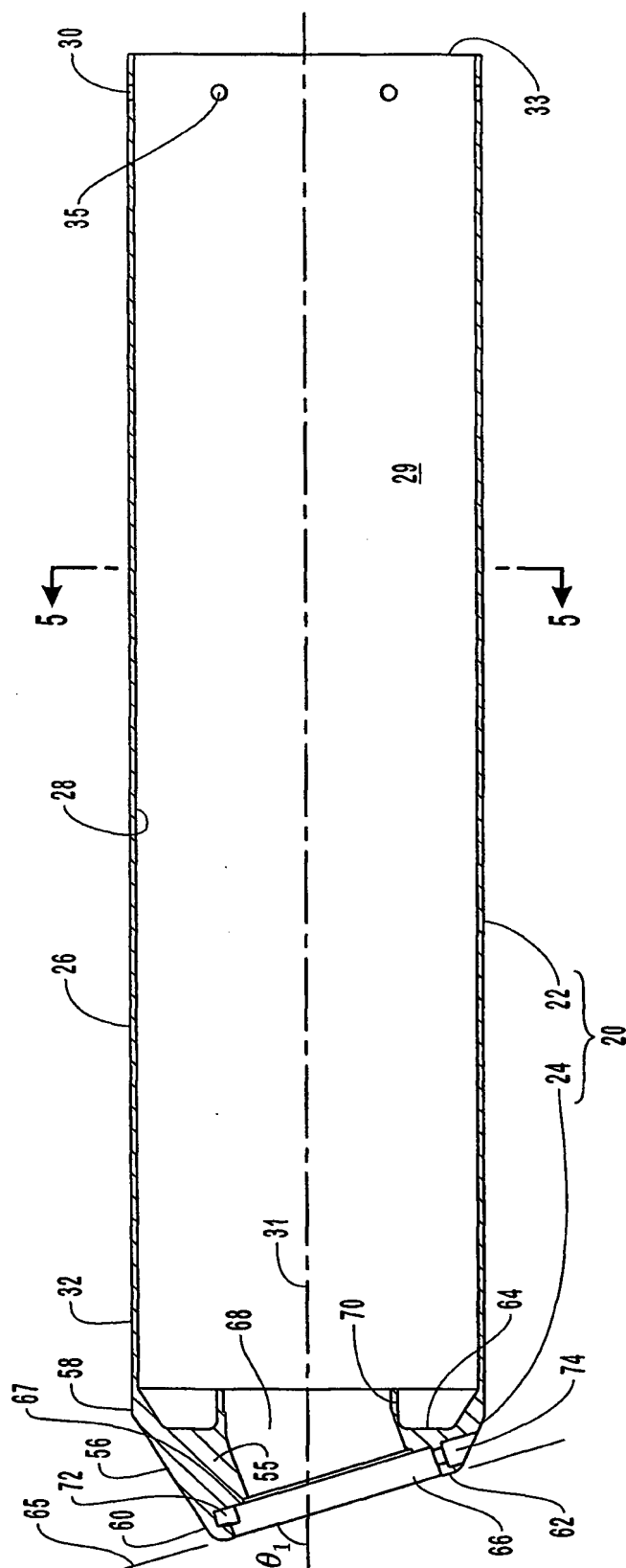


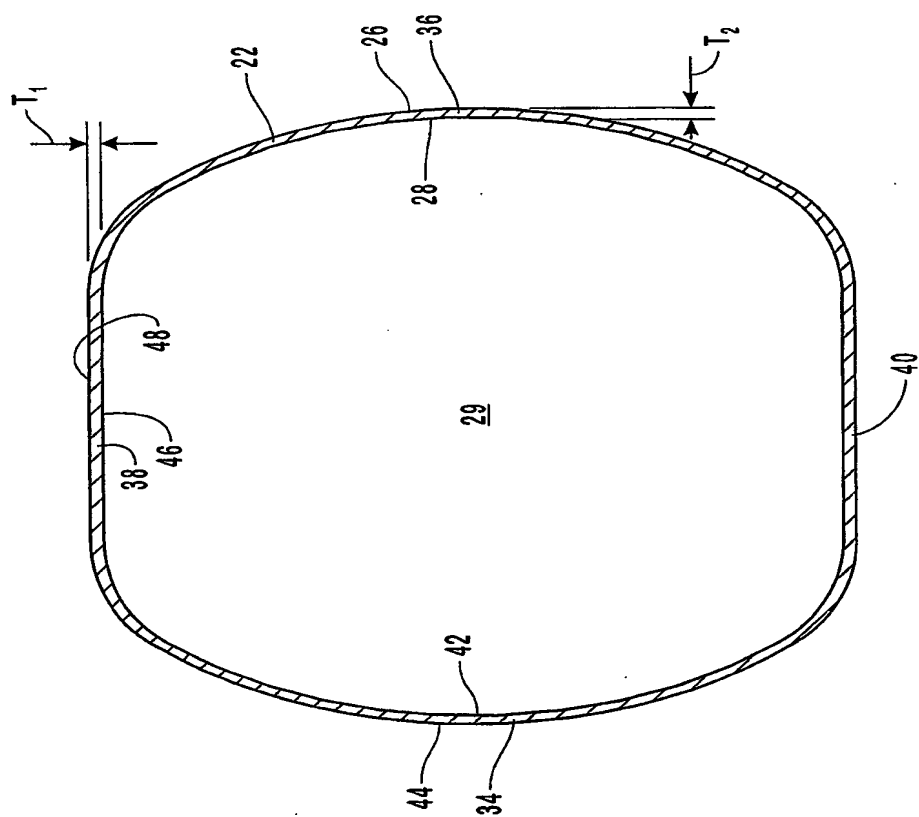
FIG. 2



**FIG. 3**



**FIG. 4**



**FIG. 5**

6 / 12

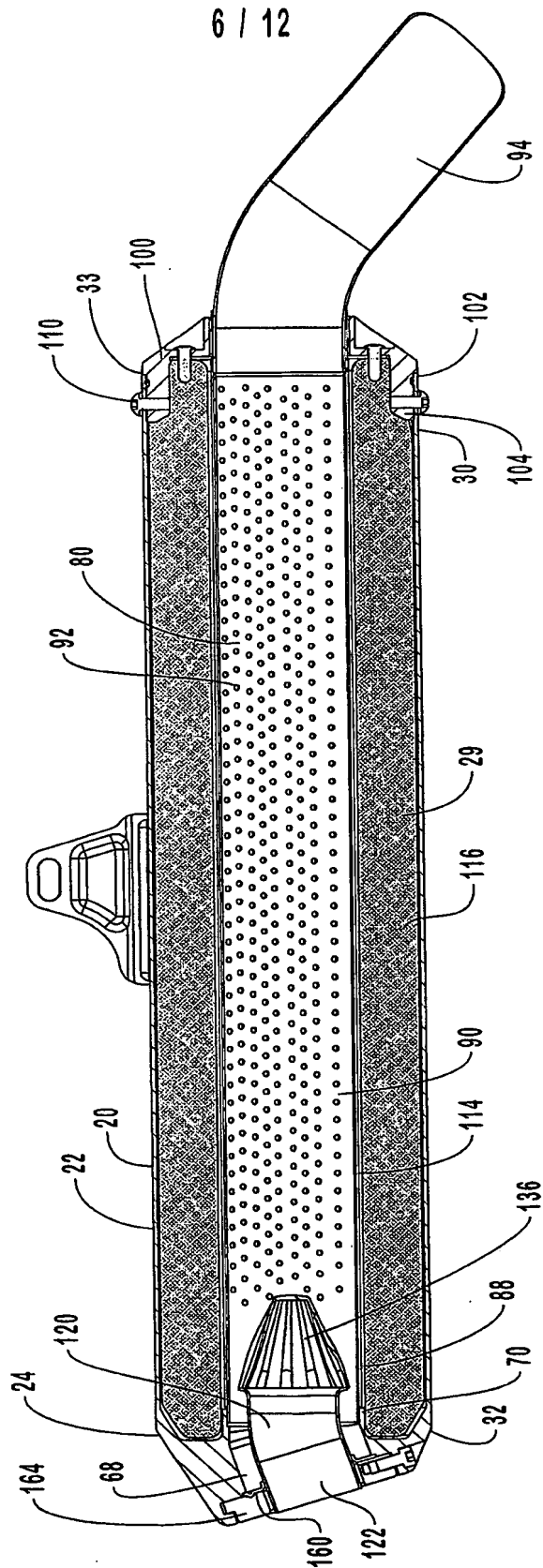


FIG. 6

7 / 12

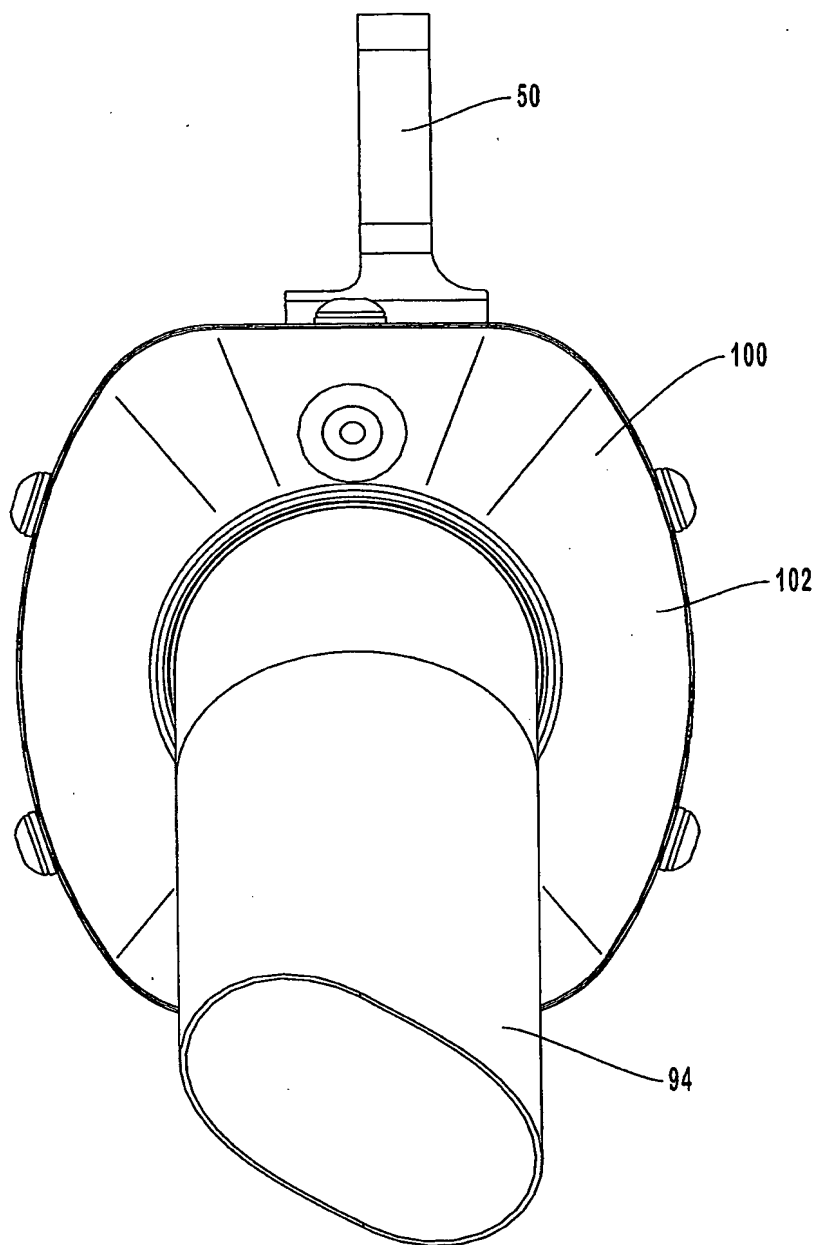


FIG. 7



8 / 12

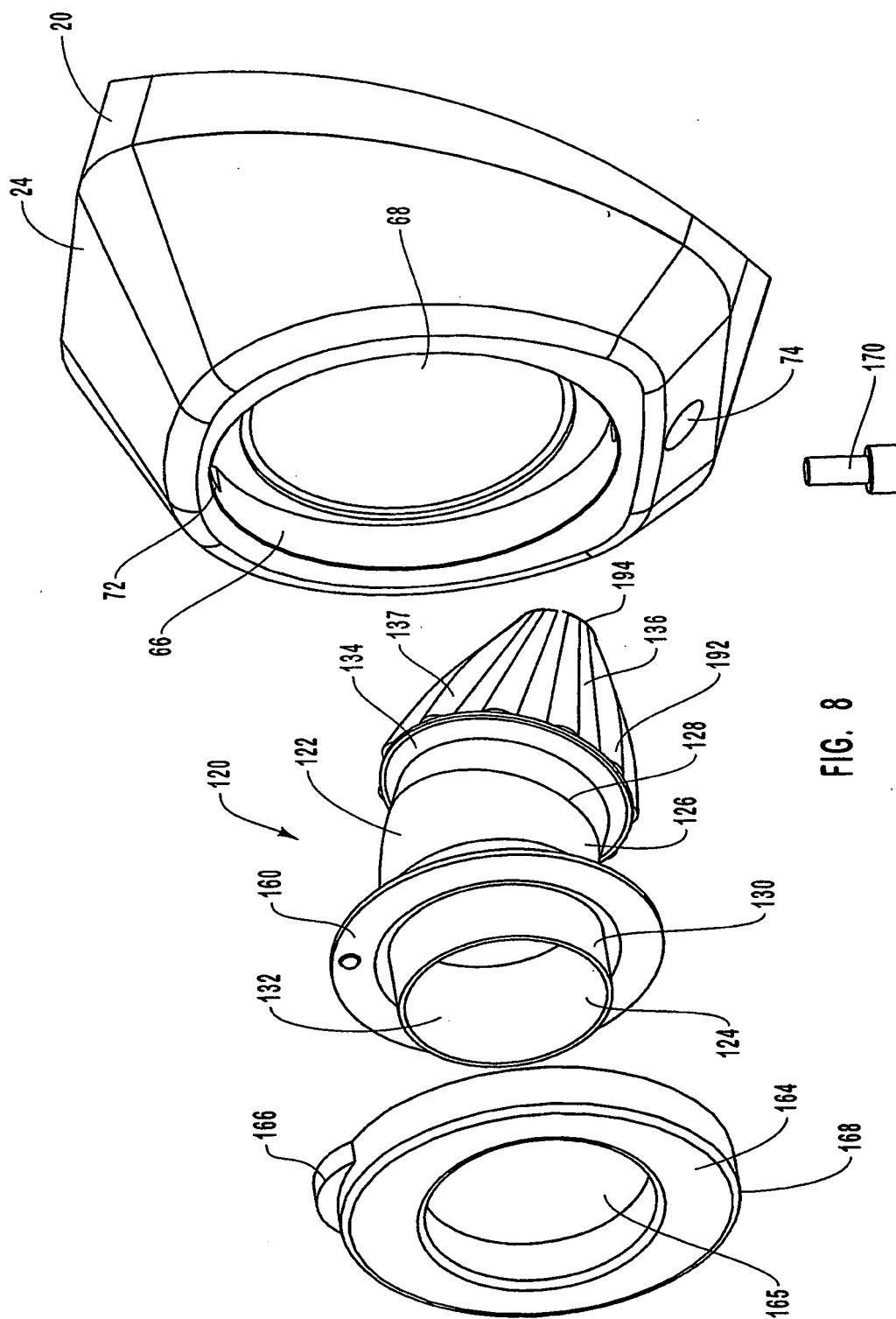


FIG. 8

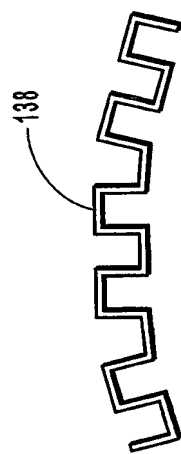


FIG. 9

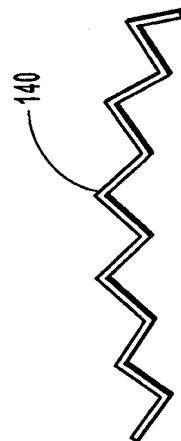


FIG. 10

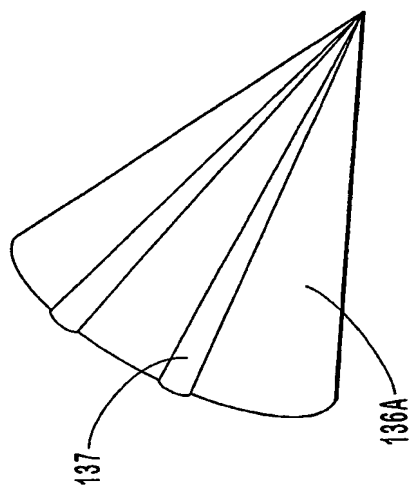


FIG. 11

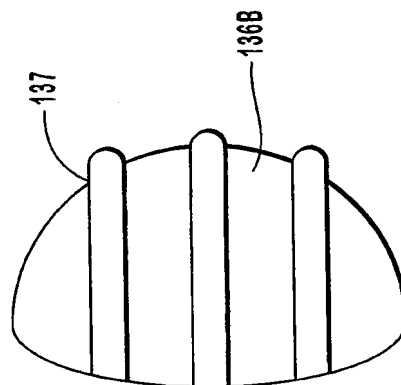


FIG. 12

10 / 12

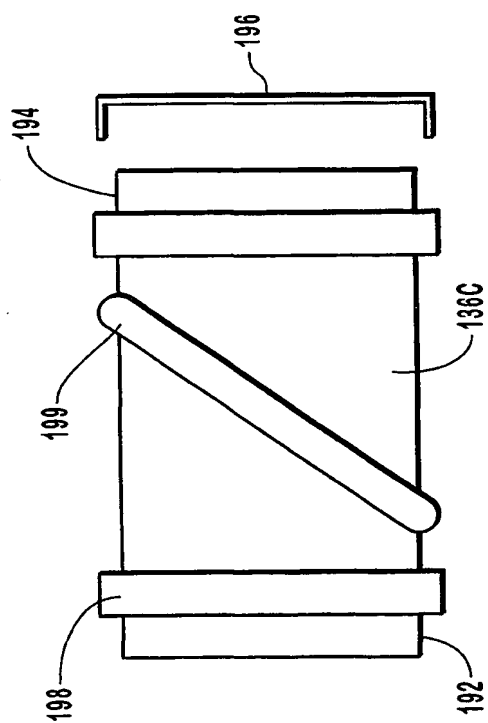
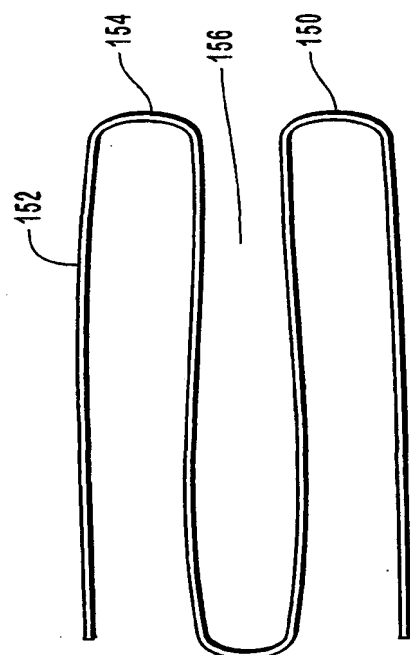
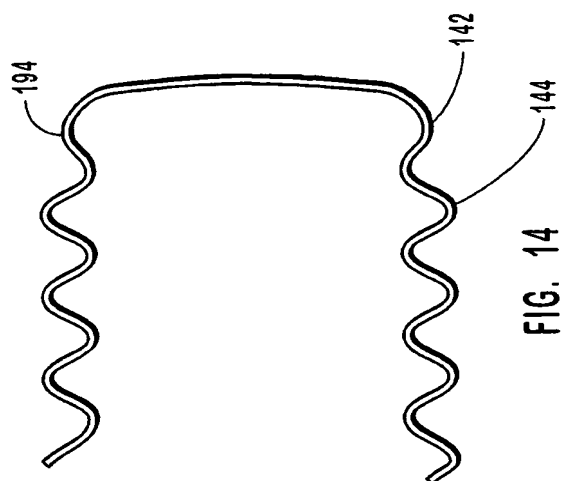


FIG. 13

FIG. 15

11 / 12

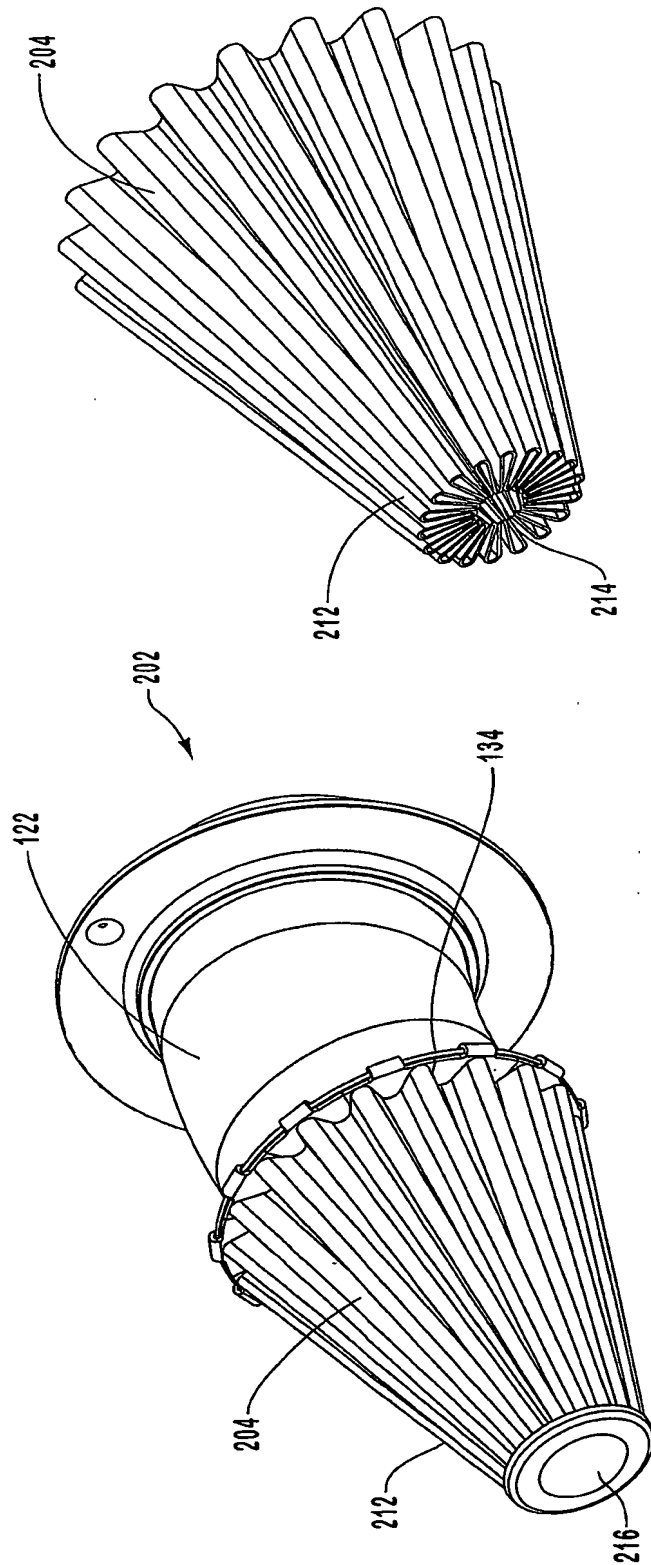


FIG. 18

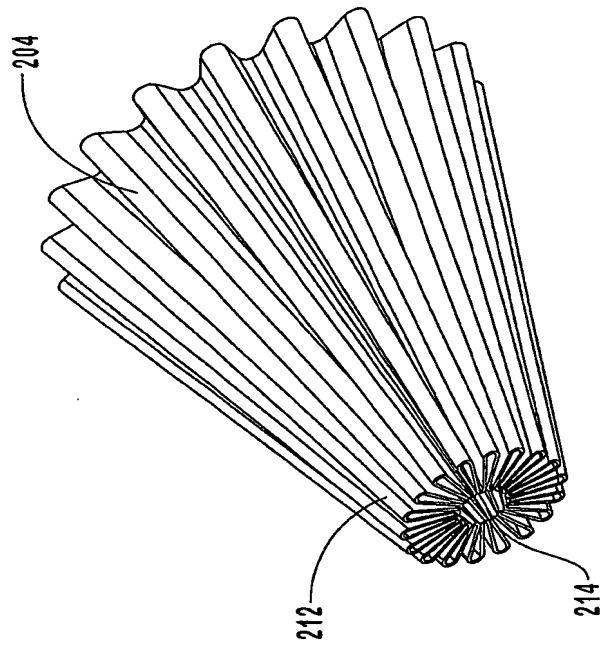
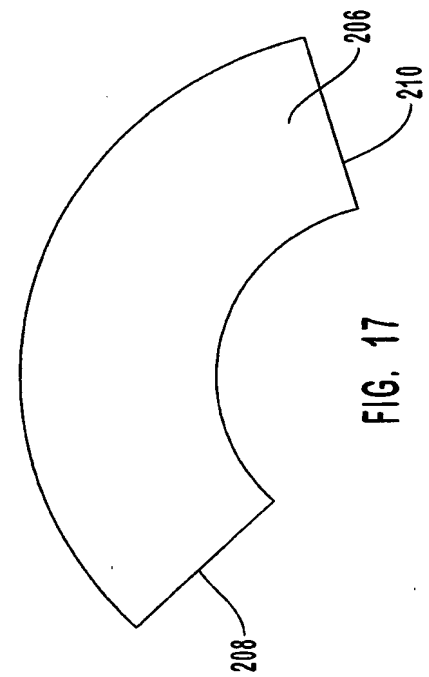


FIG. 16

FIG. 17



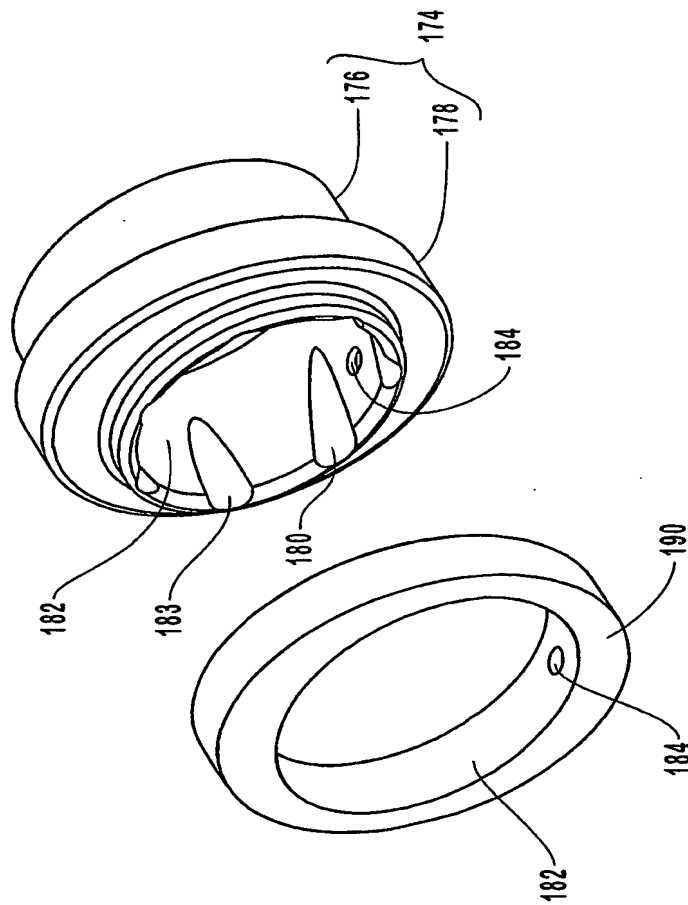


FIG. 19